Resolving size distribution of black carbon internally mixed with snow: impact on snow optical properties and albedo

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We develop a stochastic aerosol-snow albedo model that explicitly resolves the size distribution of aerosols internally mixed with various snow grains, based on a geometric-optics surface-wave (GOS) approach. We use the model to quantify effects of black carbon (BC) size distribution on snow albedo and optical properties for BC-snow internal mixing. Results show that BC-induced snow single-scattering coalbedo enhancement and albedo reduction decrease by a factor of 2–3 with increasing BC effective radii from 0.05 to 0.25 μm, while polydisperse BC results in up to 40% smaller visible single-scattering coalbedo enhancement and albedo reduction, compared to monodisperse BC with equivalent effective radii. We further develop parameterizations for BC size effects for application to climate models. Compared with a realistic polydisperse assumption and observed shifts to larger BC sizes in snow, respectively, assuming monodisperse BC and typical atmospheric BC effective radii inside snow grains could lead to overestimates of ~24% and ~40% in BC-snow albedo forcing averaged over different BC and snow conditions.

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